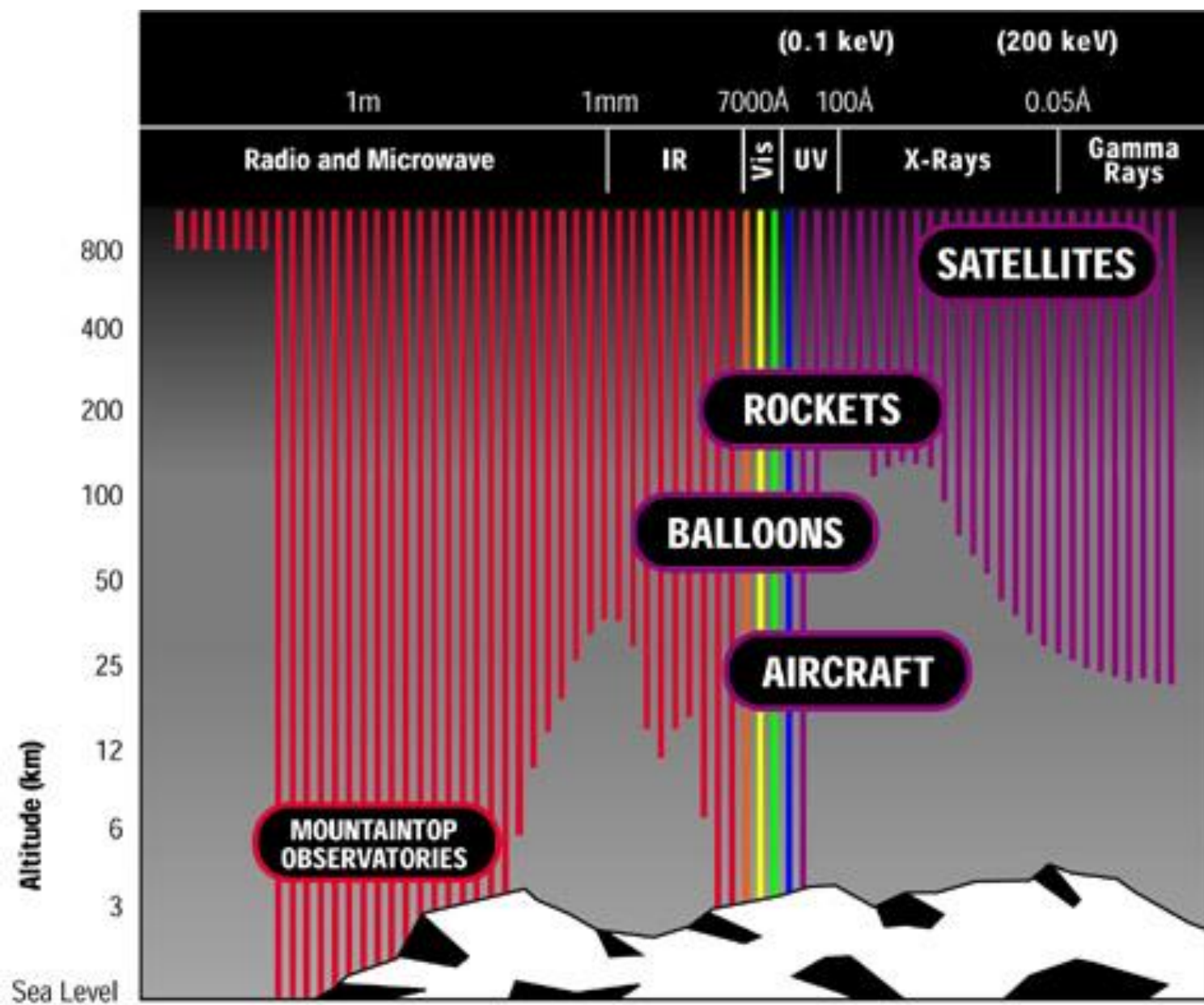


Gamma-Ray Bursts

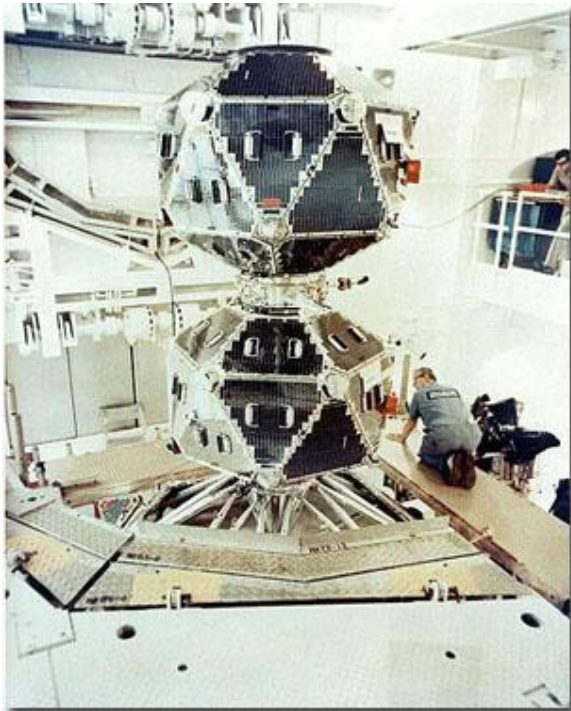
Gerald J. (Jerry) Fishman

NASA-Marshall Space Flight Center
Huntsville, AL USA

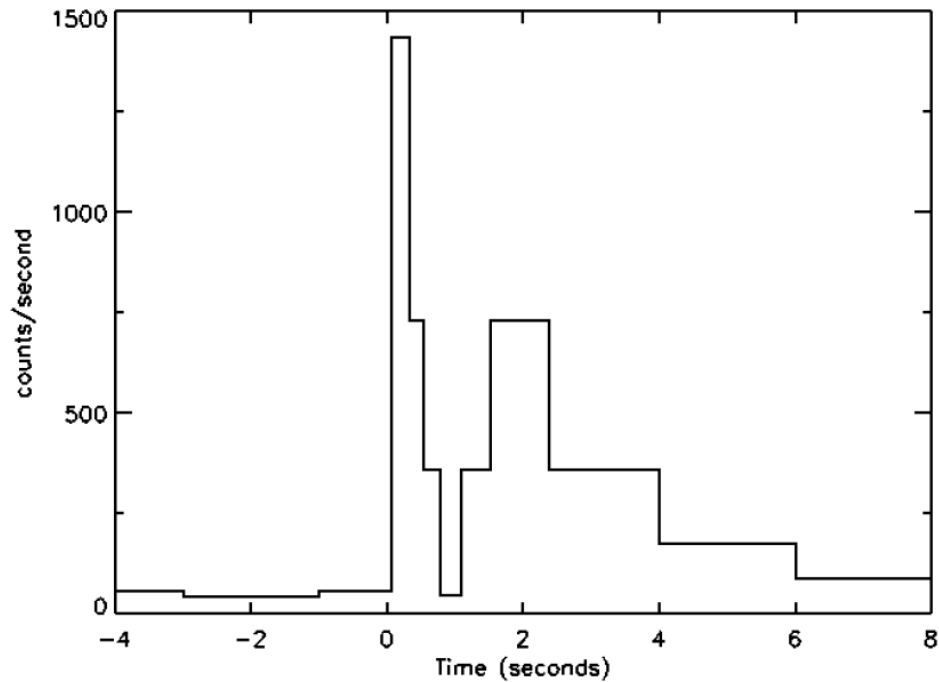
*Physics Department
University of Missouri
March 19, 2012*



Vela Spacecraft for Nuclear Bomb Detection in Space

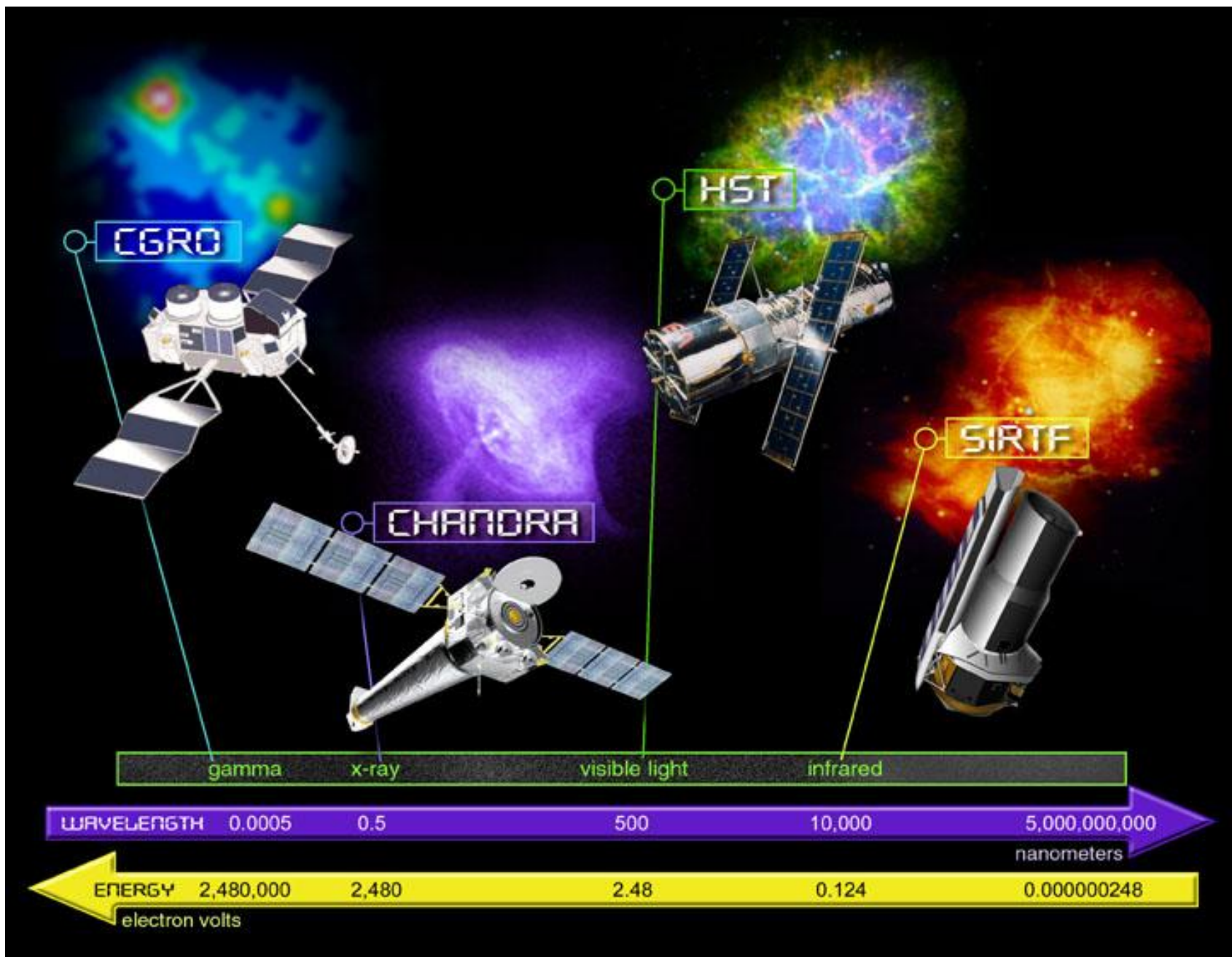


The First Gamma-ray Burst (GRB) Observed with Vela Spacecraft 1967



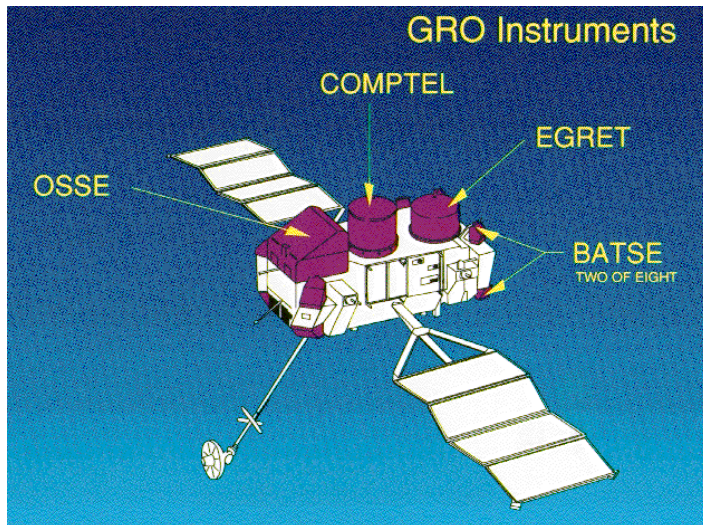
NASA's Four Great Observatories:

	<u>Launch - End</u>
Hubble Space Telescope	1990 - ~2015
Compton Gamma-Ray Observatory	1991 - 2000
Chandra X-Ray Observatory	1999 - ~2020
Spitzer Space Infrared Telescope	2003 - ~2015

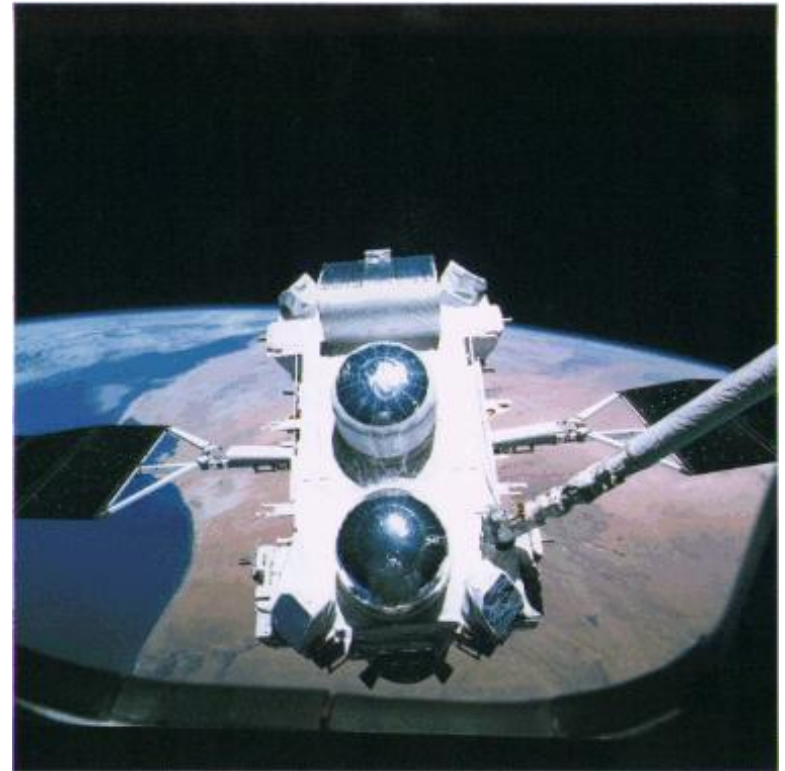
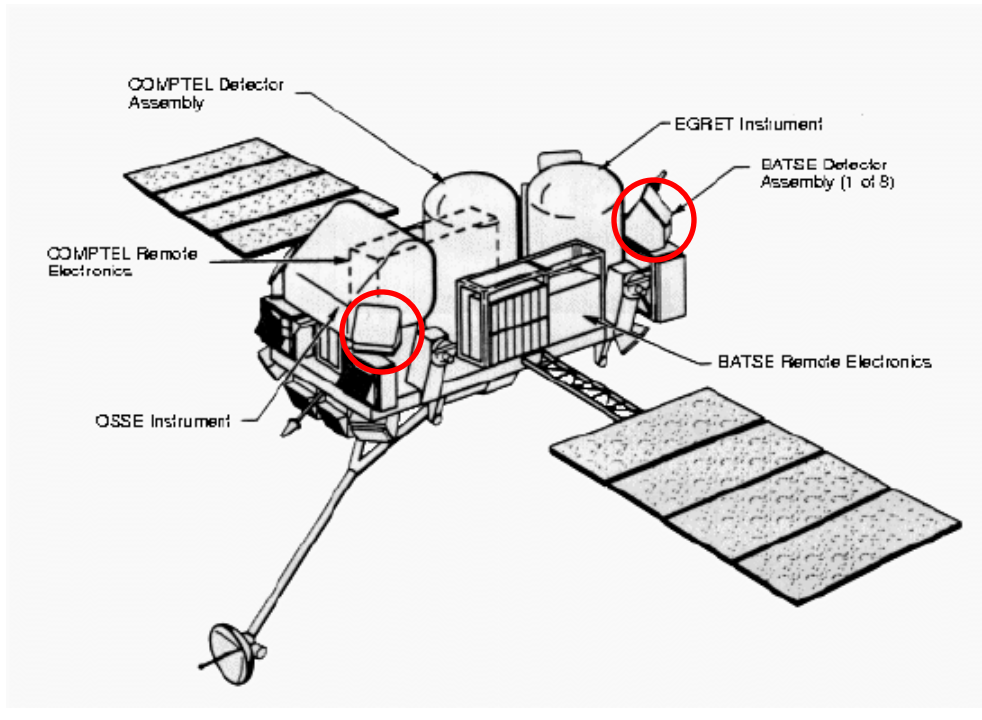


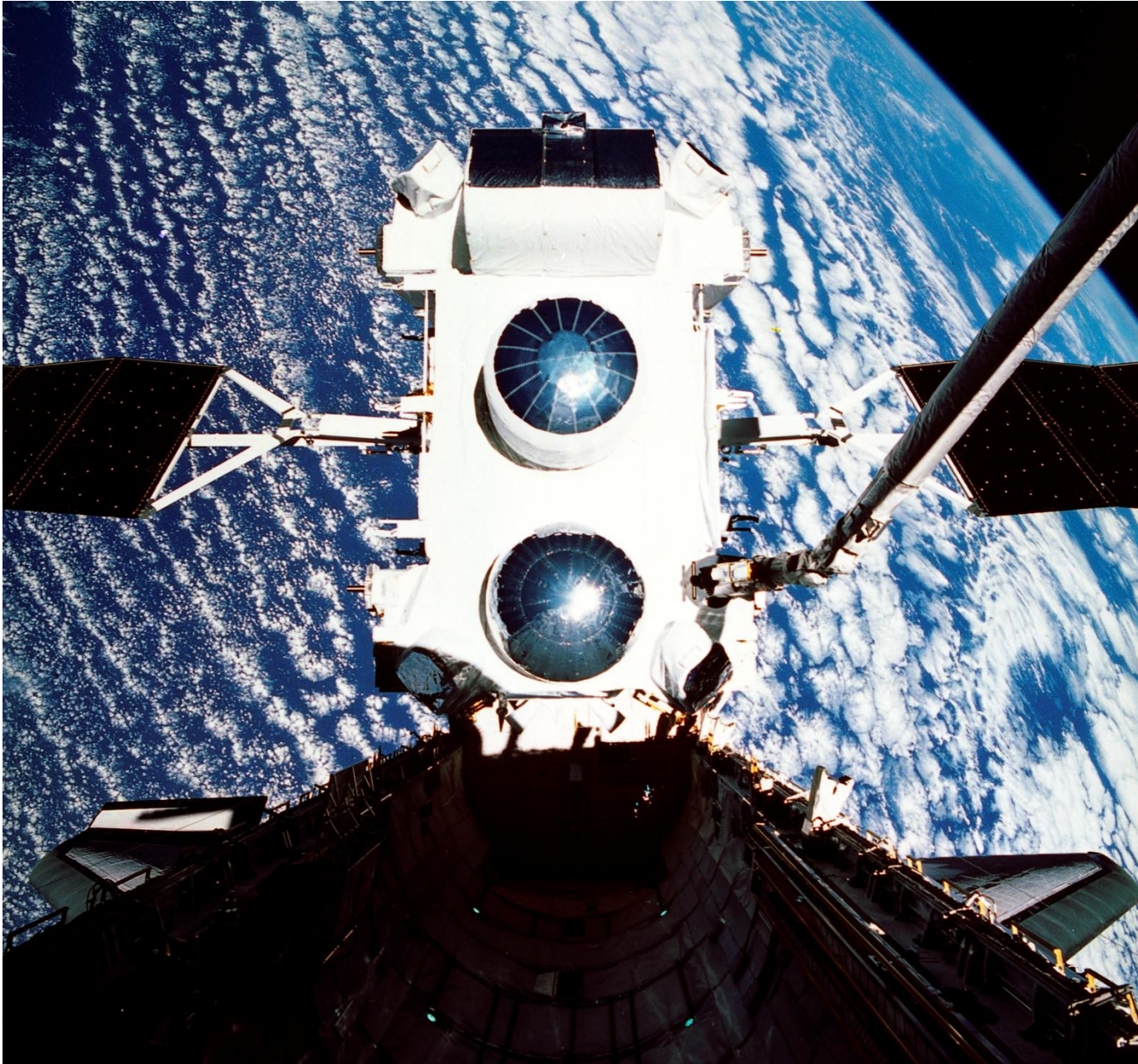
1991 - CGRO

NASA launched the
Compton Gamma Ray
Observatory (CGRO)



Burst and Transient Source Experiment (BATSE) on the Compton Observatory

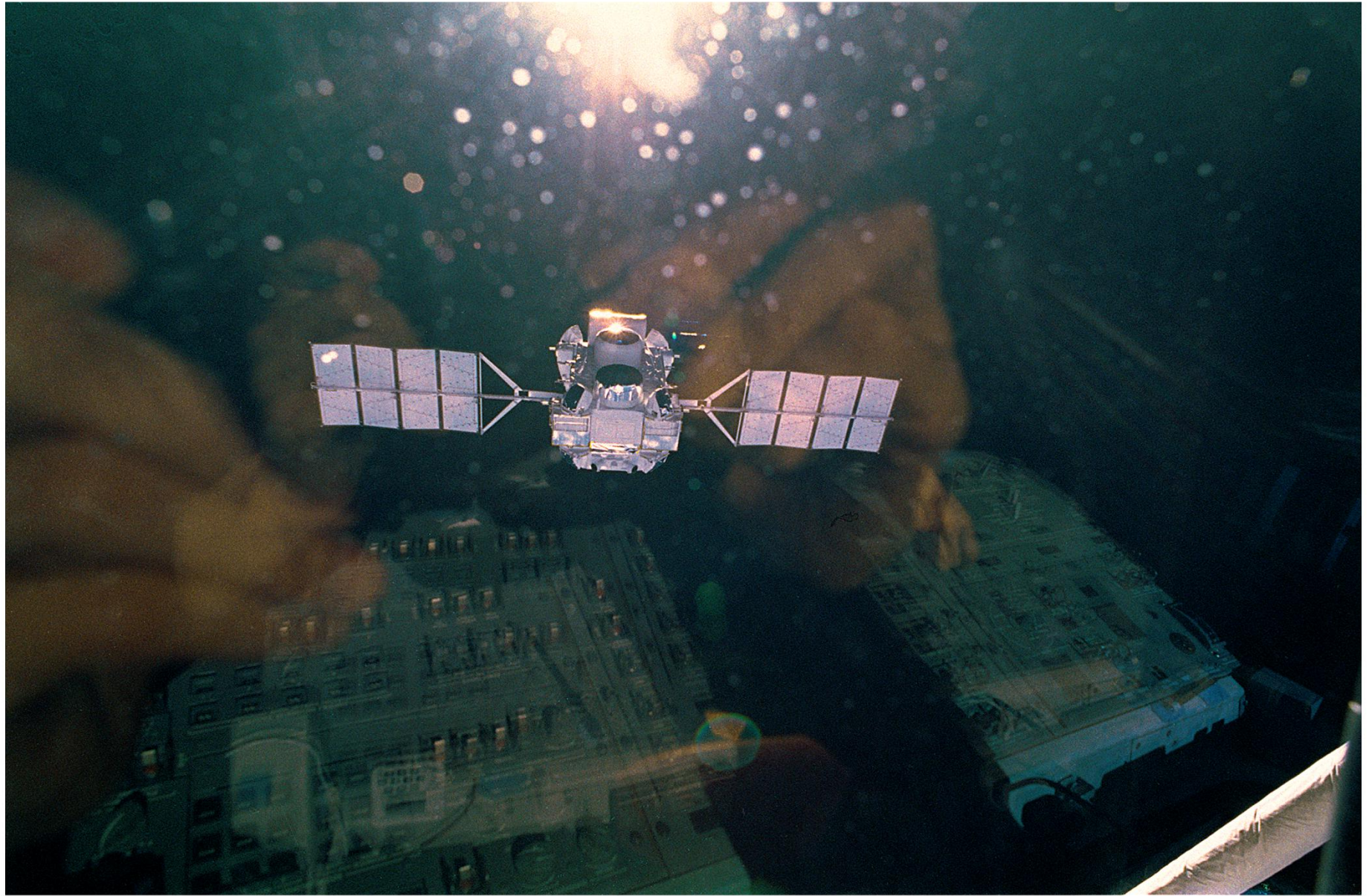




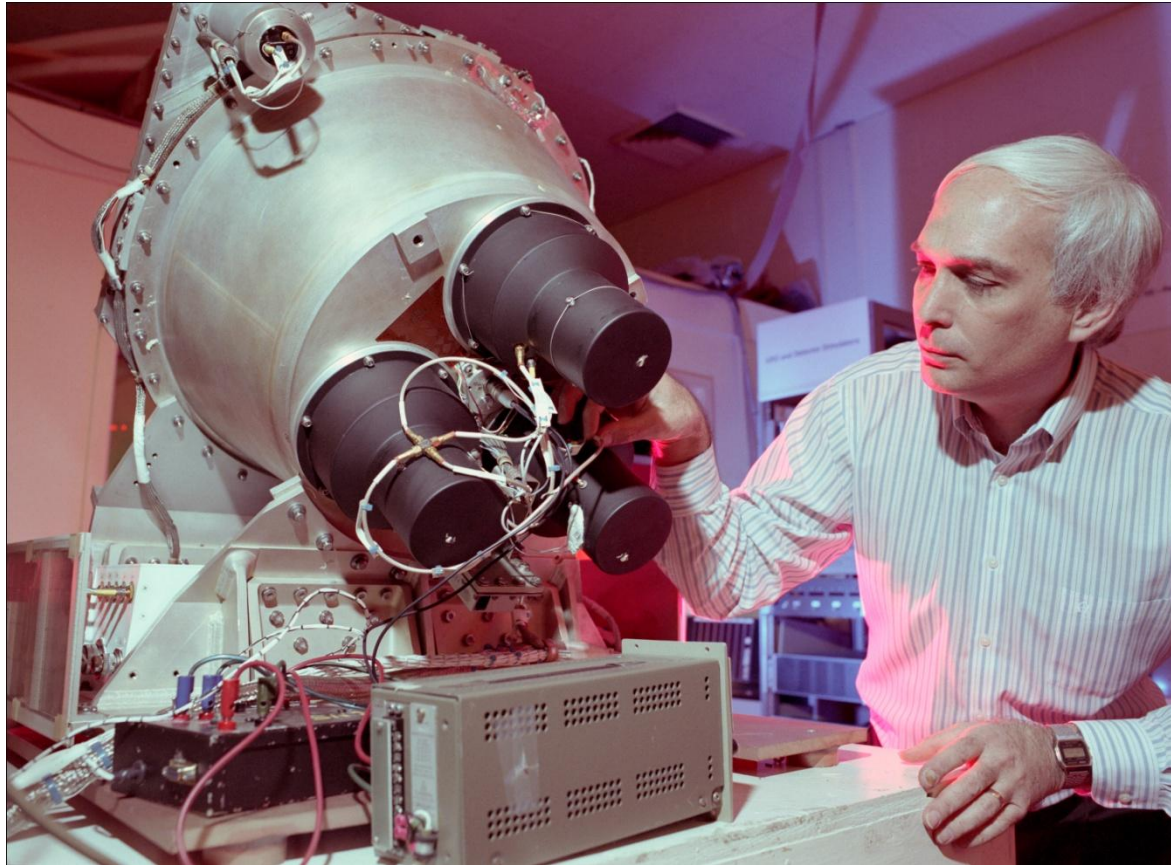




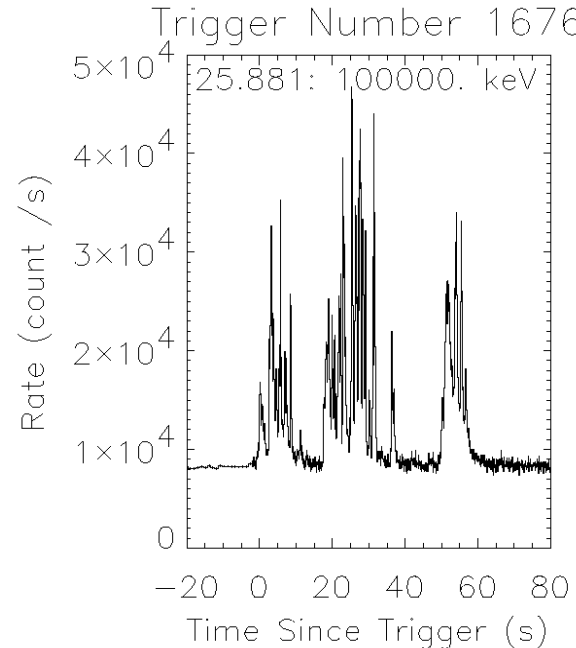
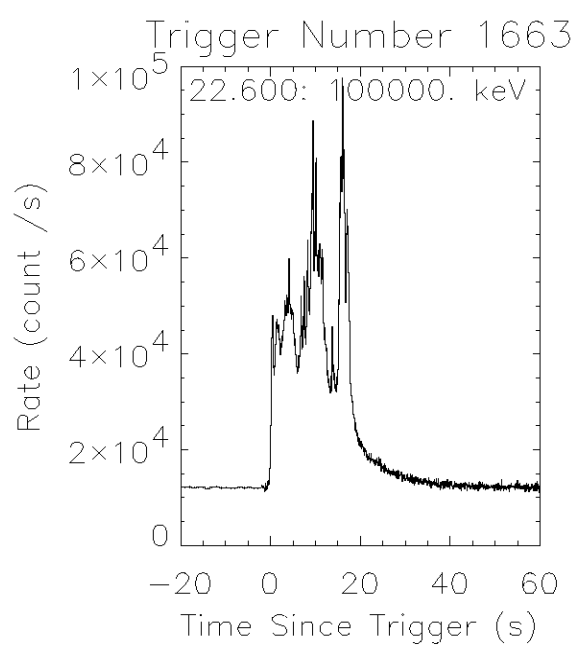
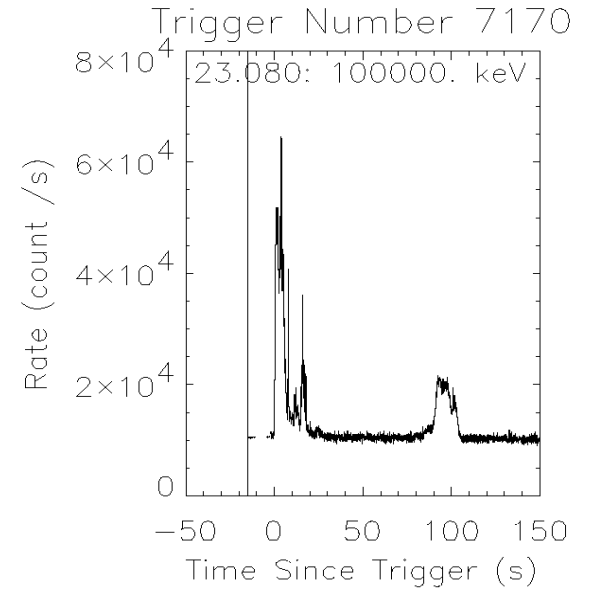
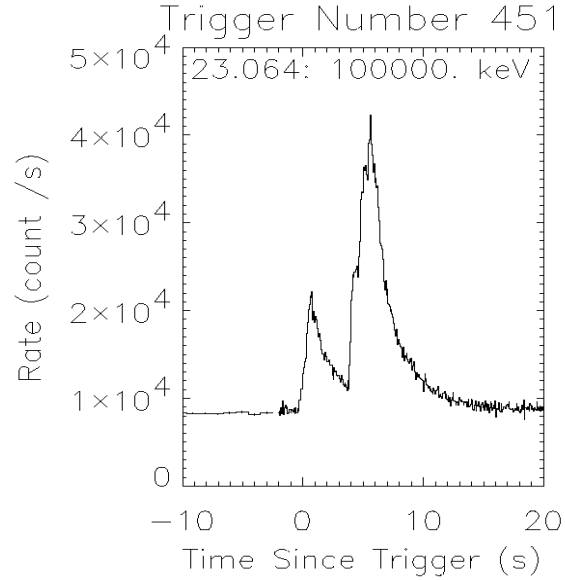
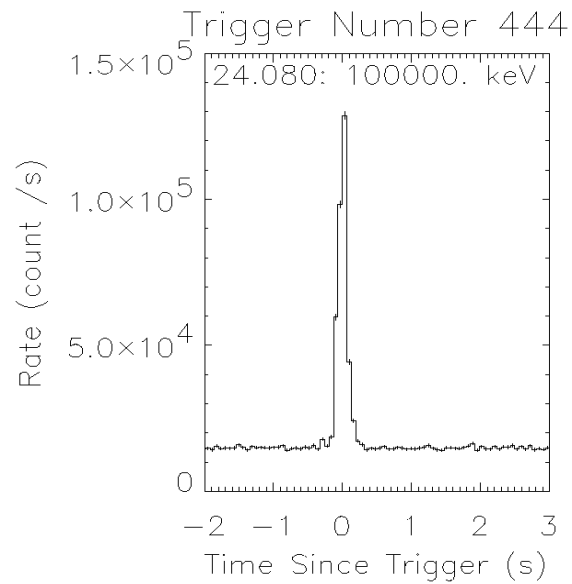


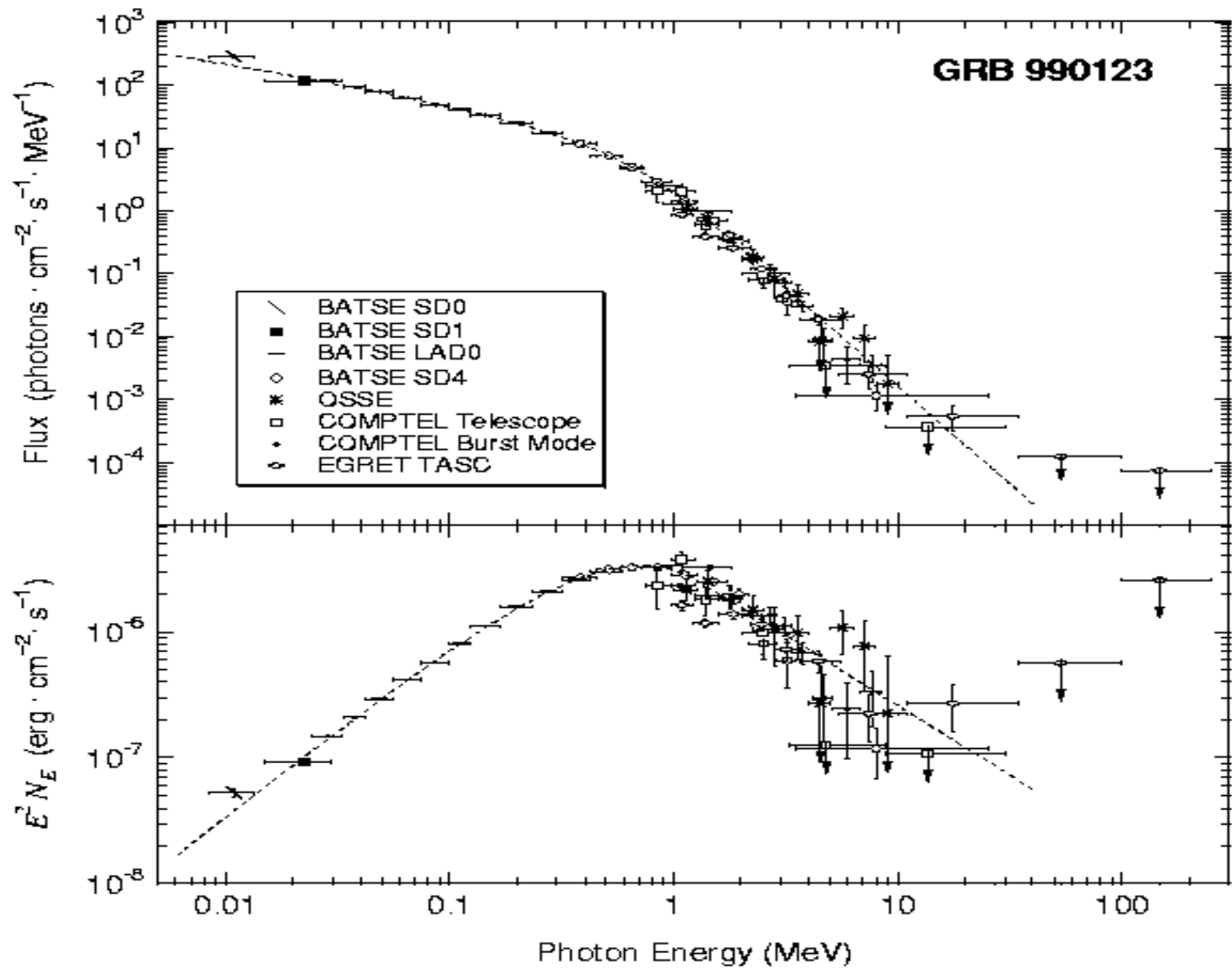


BATSE Detector Module



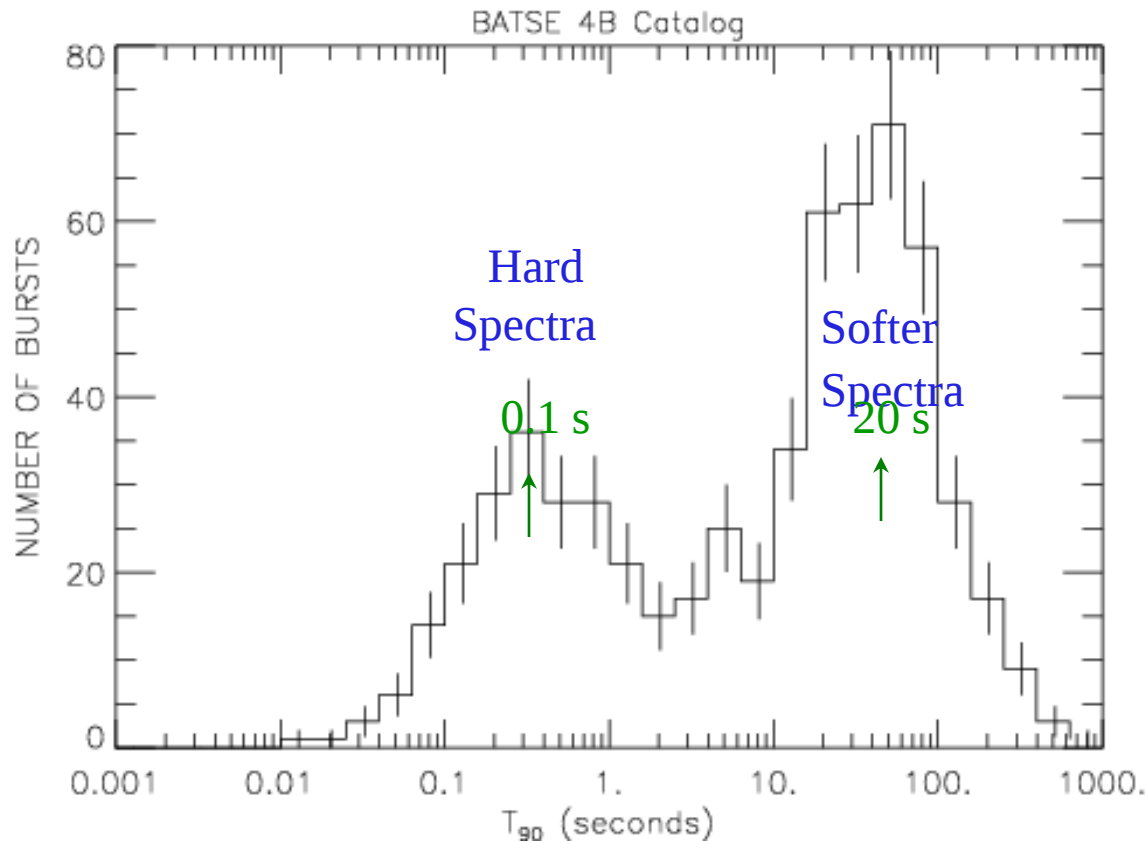
Diversity of GRB Profiles

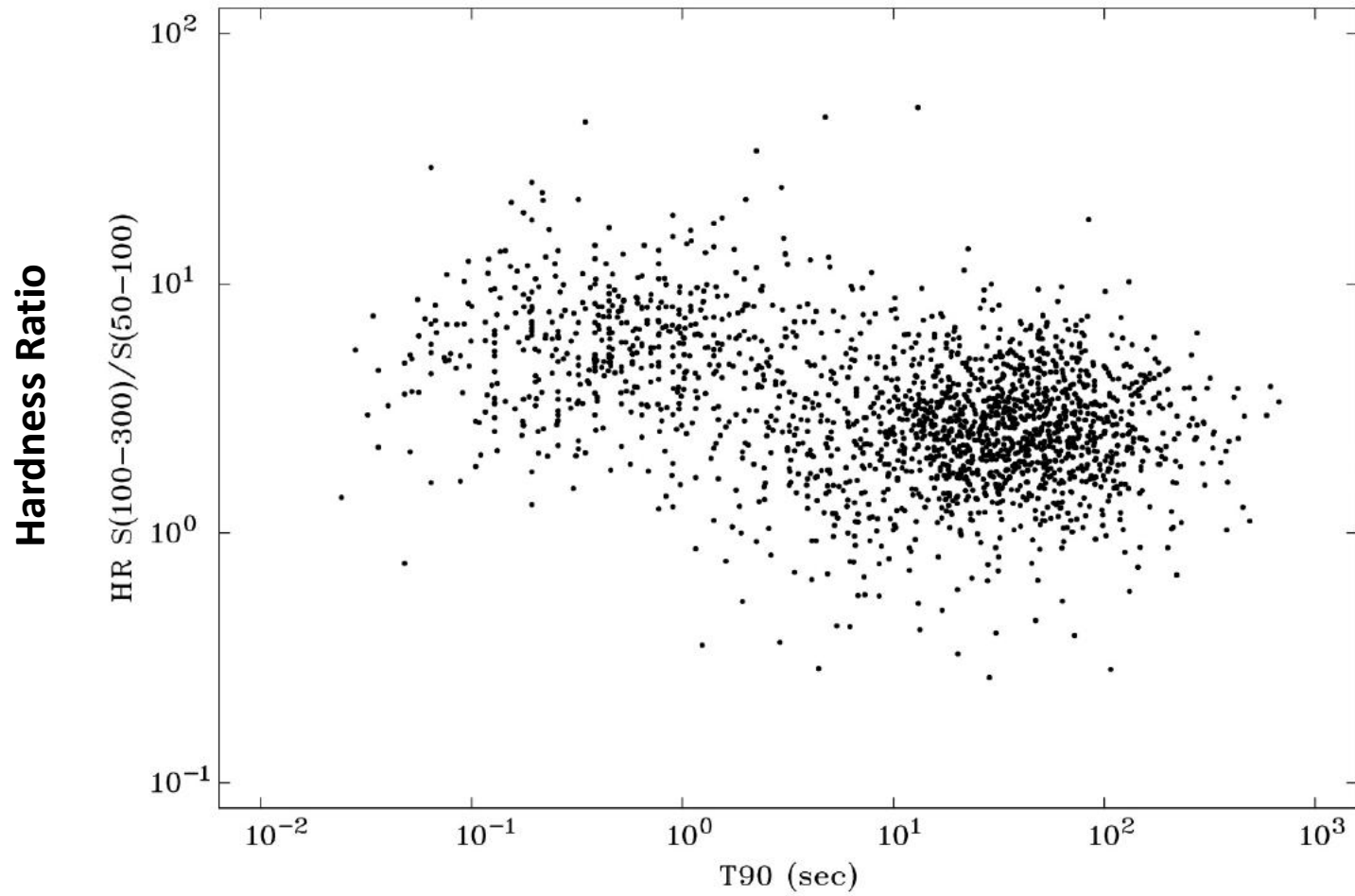




Two Distinct subclasses of γ -ray bursts:

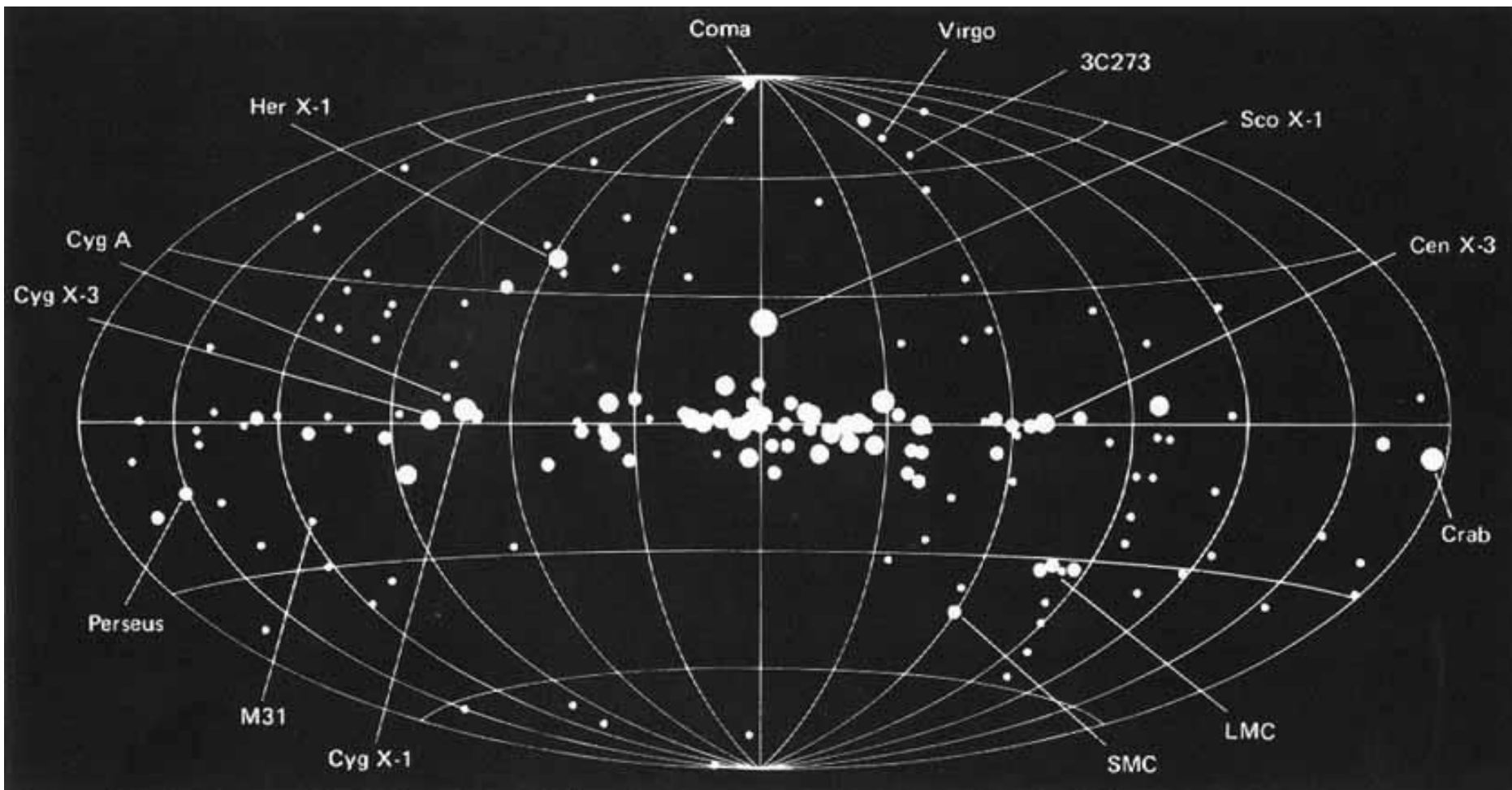
short/hard & long/soft

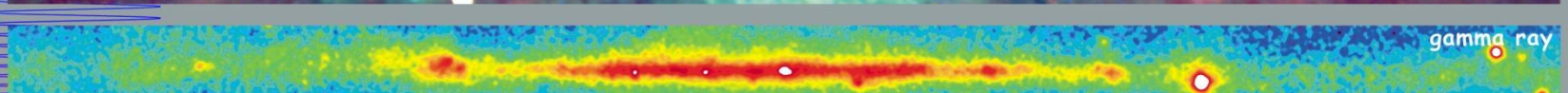
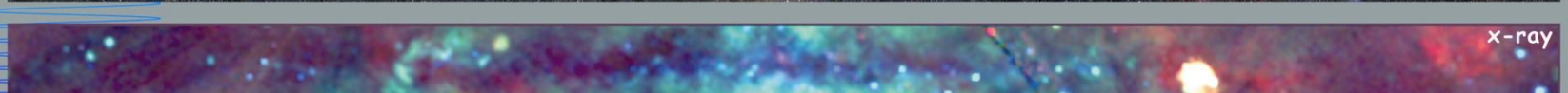
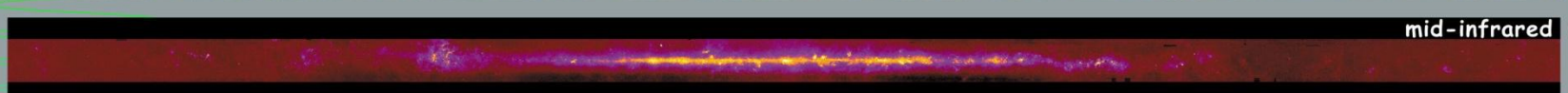
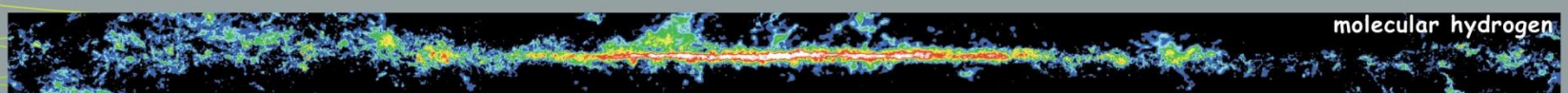
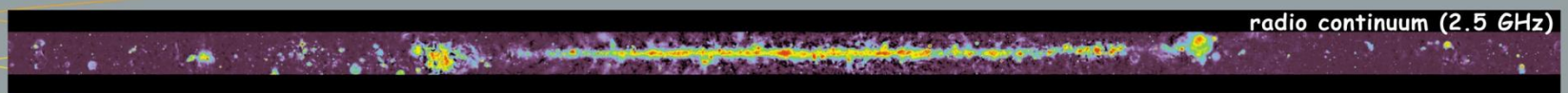
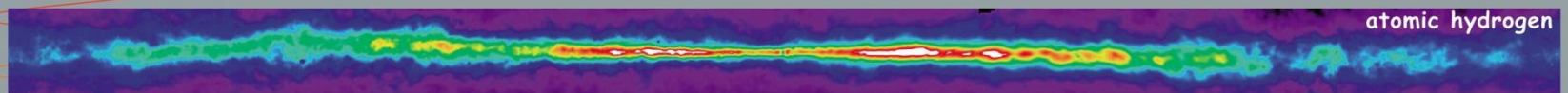
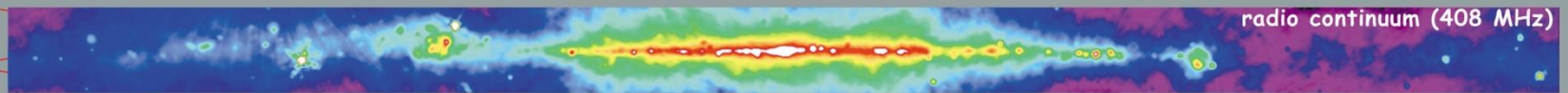




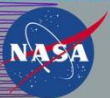
Duration of Gamma-ray Bursts (sec)

X-ray Objects in the Sky

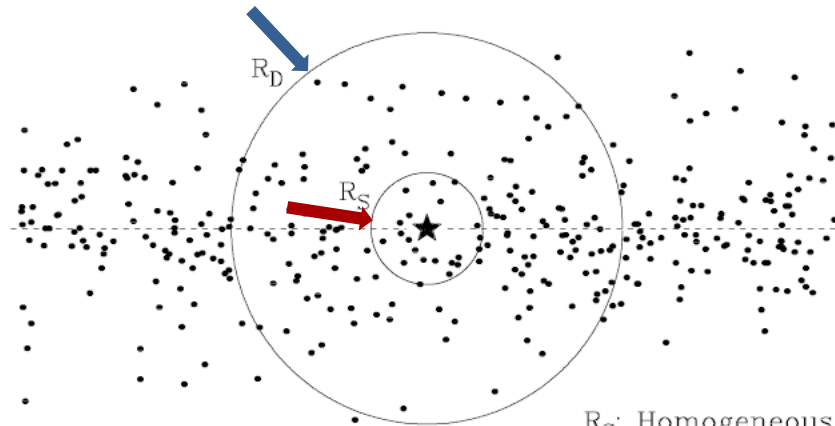




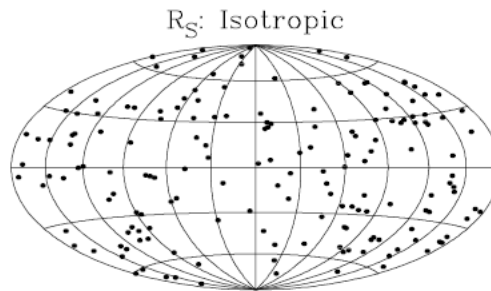
<http://adc.gsfc.nasa.gov/mw/>



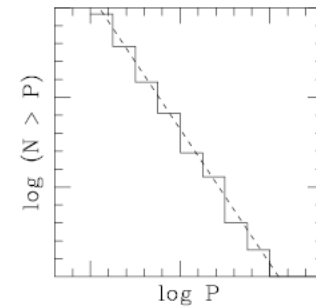
Multiwavelength Milky Way



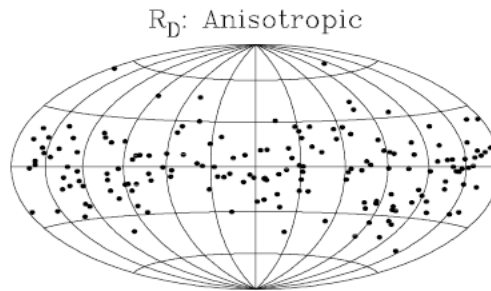
R_S - Galactic, Nearby



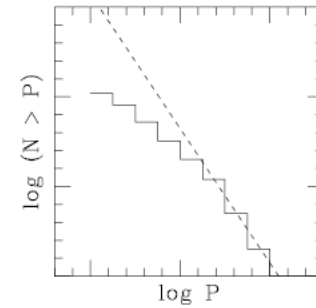
R_S : Homogeneous



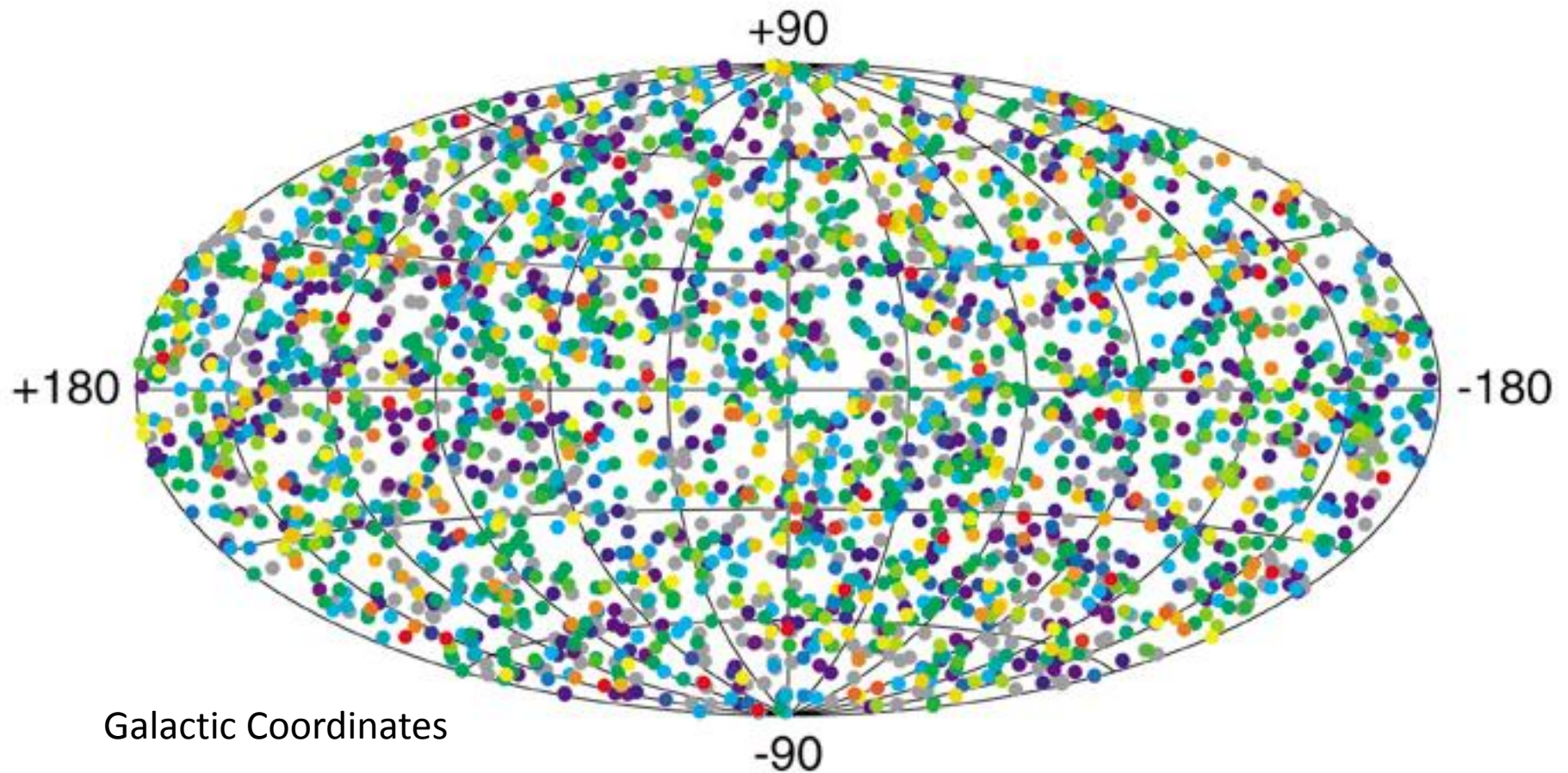
R_D - Galactic, Far away



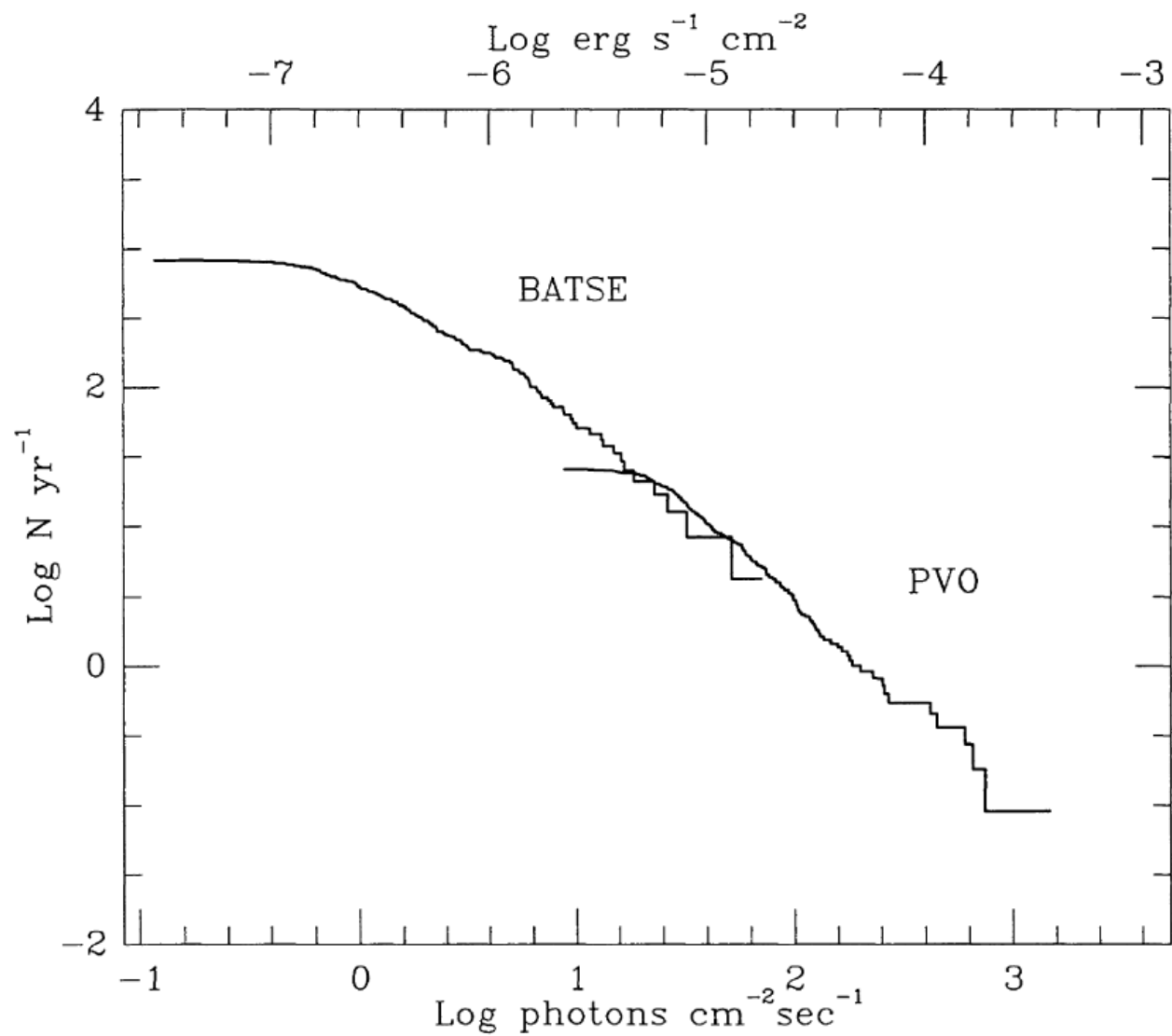
R_D : Inhomogeneous

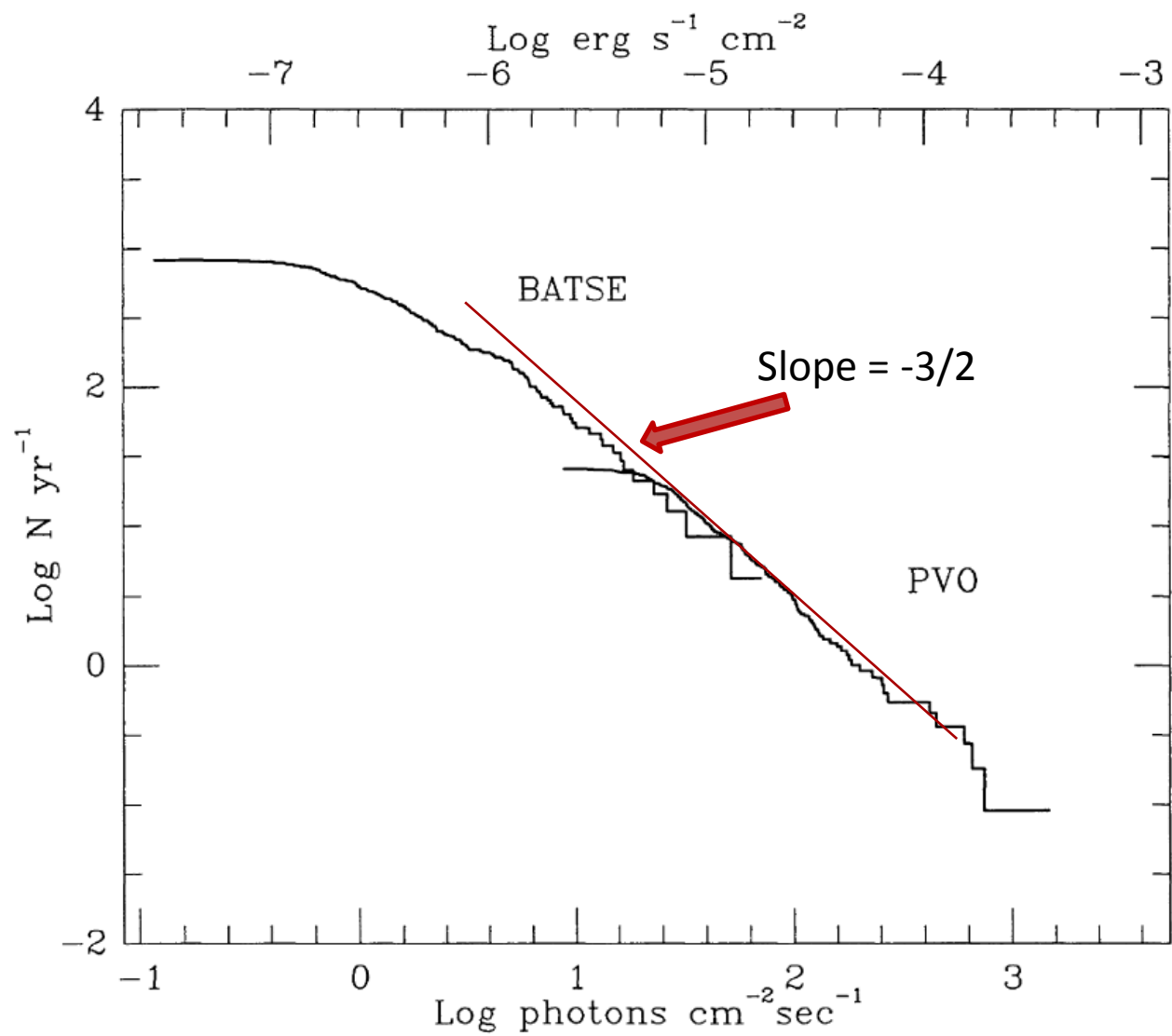


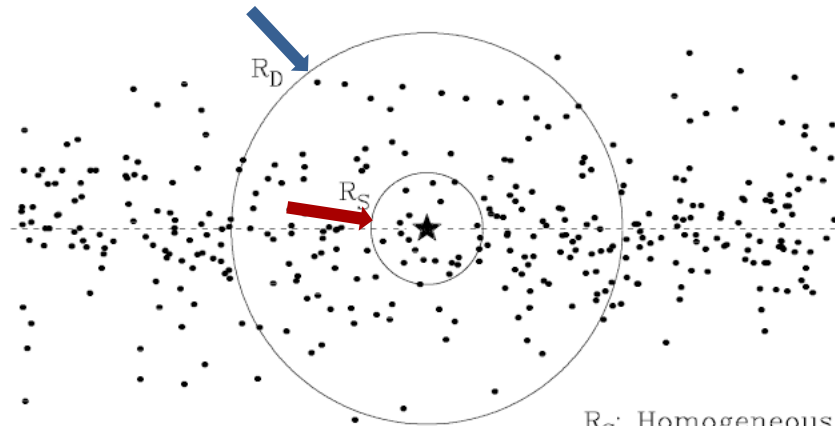
2704 BATSE Gamma-Ray Bursts



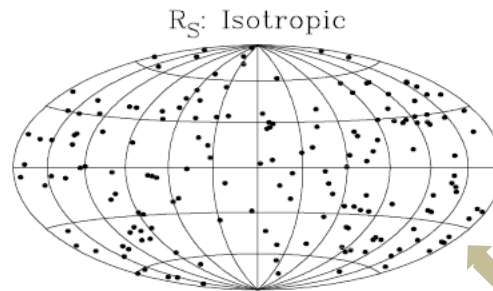
Apr. 1991 – May 2000



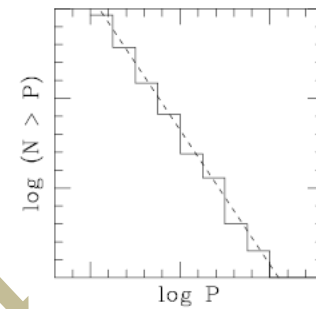




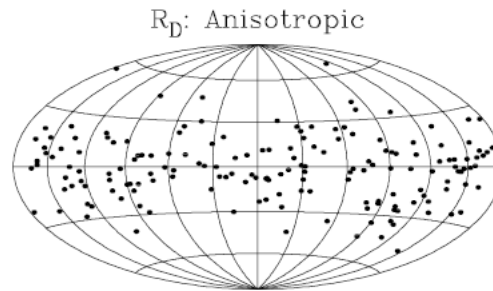
R_S - Galactic, Nearby



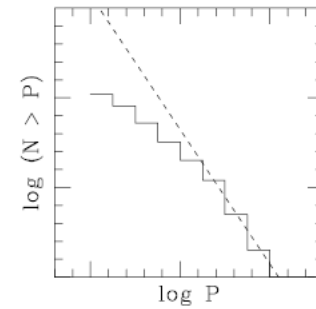
R_S : Homogeneous



R_D - Galactic, Far away



R_D : Inhomogeneous



From BATSE Observations:

**The Gamma-ray Burst Distribution
is not like that of
any known Objects in our Galaxy
and thus they are *likely* at
Cosmological Distances***

*** - Near the Edge of the Observable Universe**

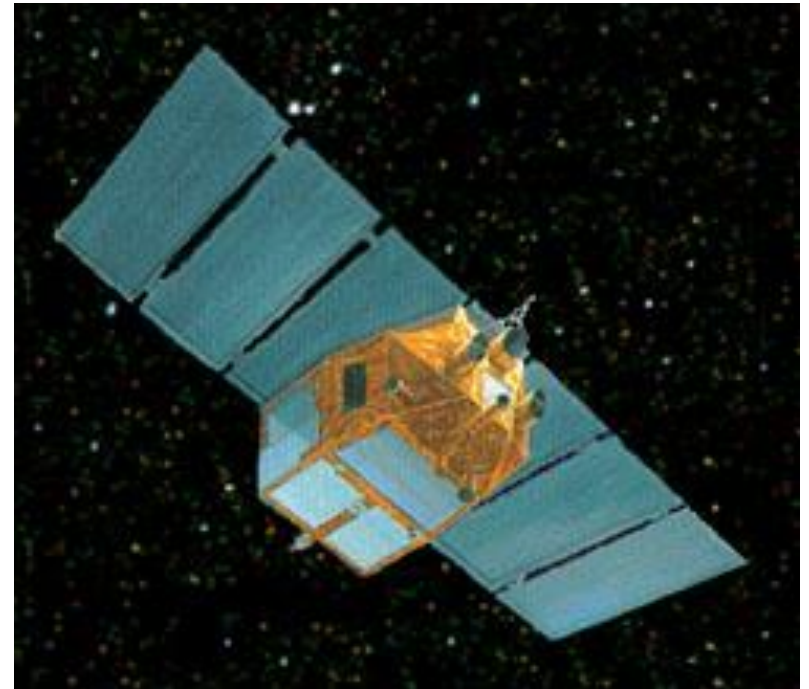
1992-1996:

Hiatus in the GRB Field

- A Breakthrough is needed**

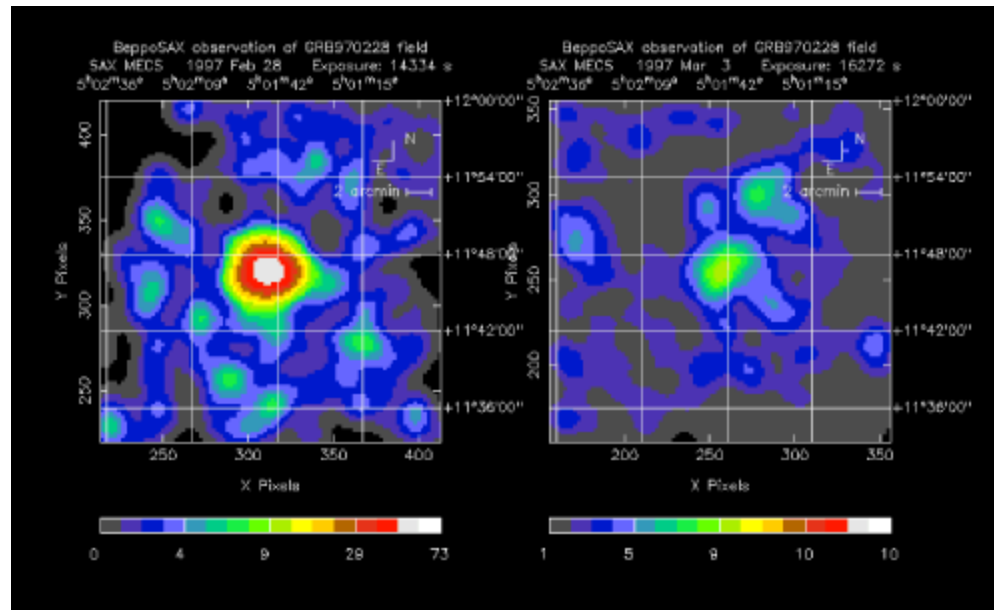
Observational Breakthrough in 1997: BeppoSAX

- Italian/Dutch satellite detected GRB 970228 and an X-ray source at the same position that decays over time.
- A visible light afterglow was found at the same position.



Observational Breakthrough in 1997:

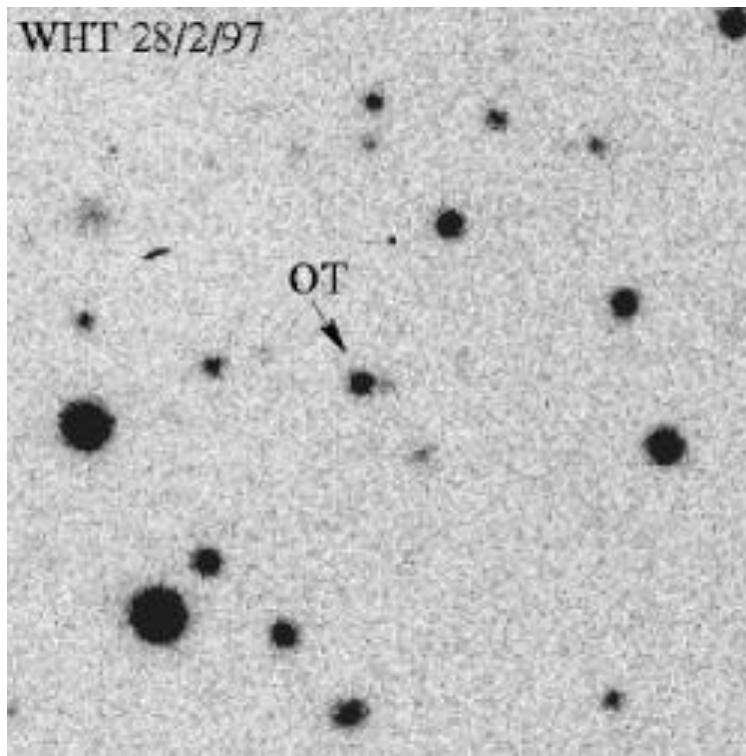
BeppoSAX Satellite



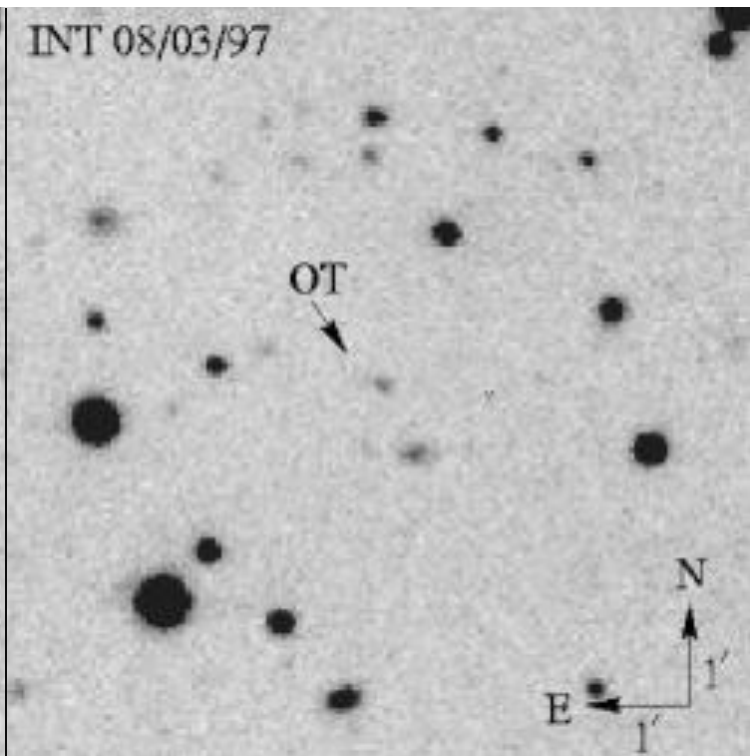
Feb. 28, 1997

Mar. 3, 1997

GRB970228 : X-ray Observations

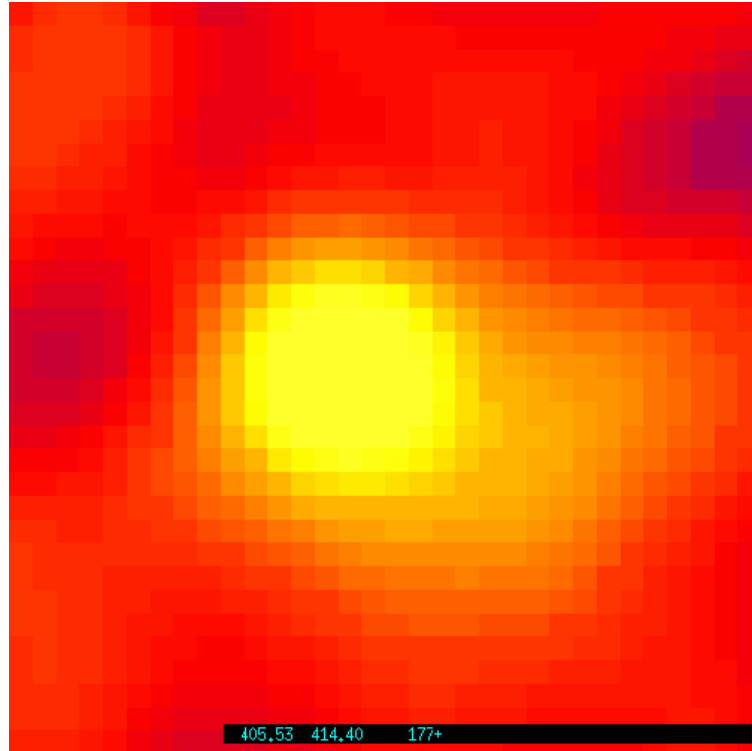


Feb. 28, 1997



Mar. 8, 1997

GRB970228 : Optical Observations

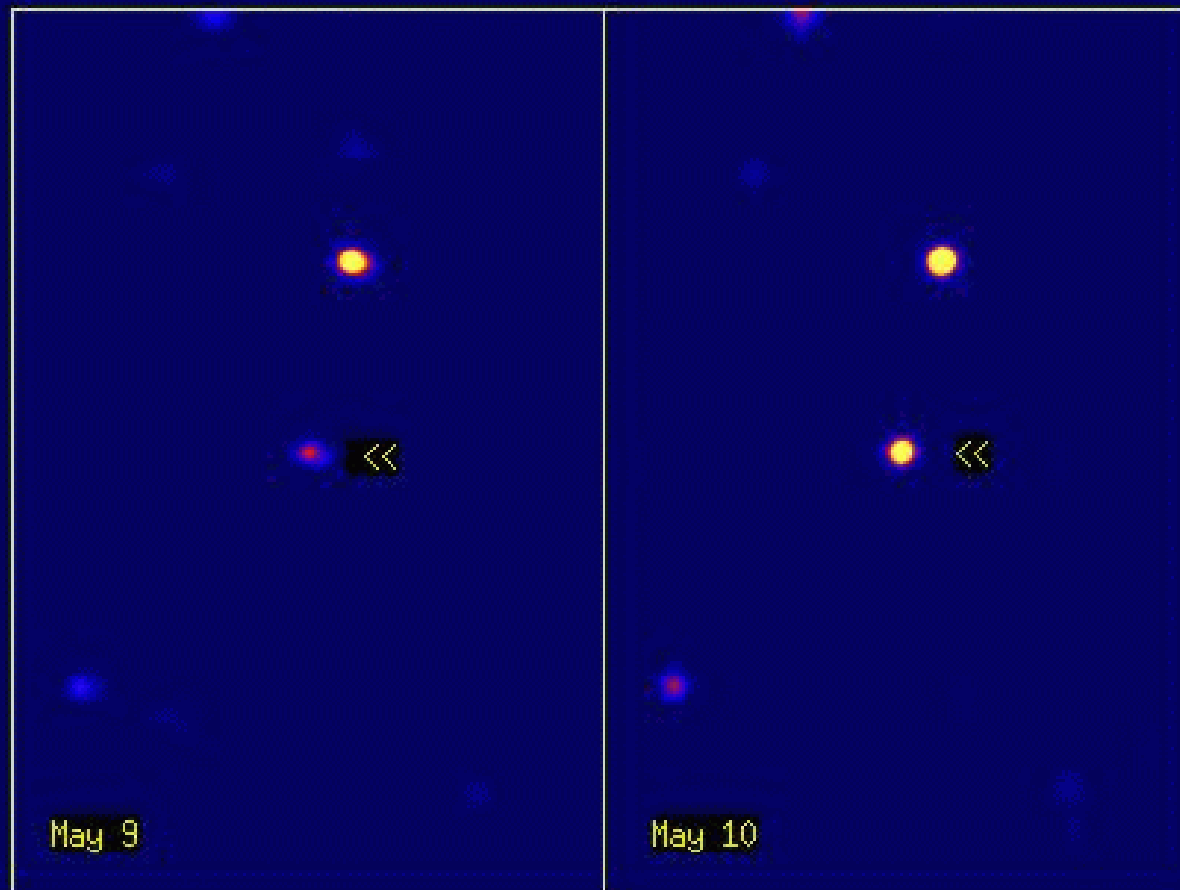


Mar. 5, 1997

Hubble Space Telescope Image of GRB970228

(Note Faint, Fuzzy Galaxy to Lower Right)

GRB 970508 Optical Counterpart



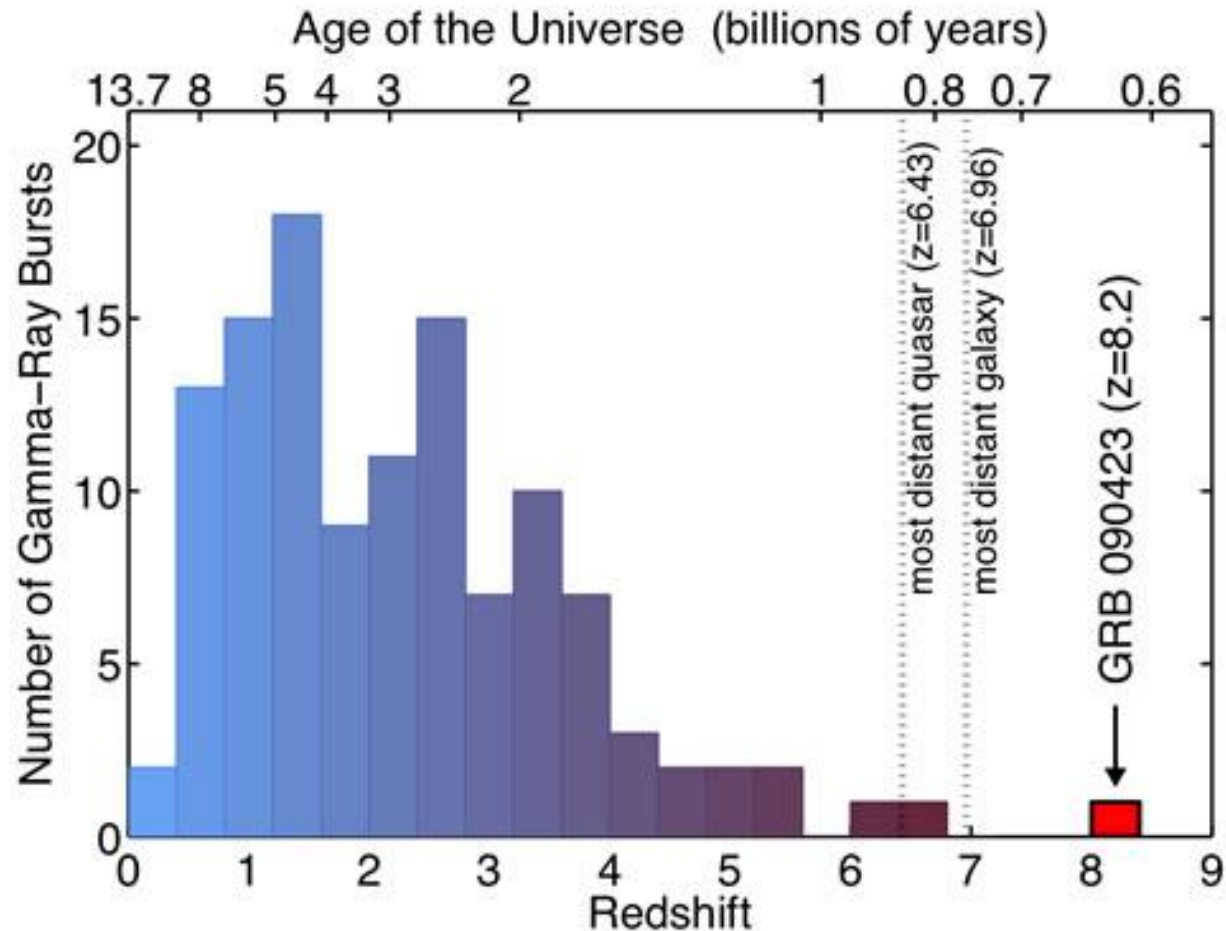
Palomar Observatory

GRBs are the Most Powerful Objects in the Universe!

GRB 990123 power (calculated from its peak magnitude and red-shift) was $\sim 2 \times 10^{54}$ ergs/sec

= 3 Billion Galaxies' Total Energy Output per sec
(1 Galaxy = 100 Billion stars)

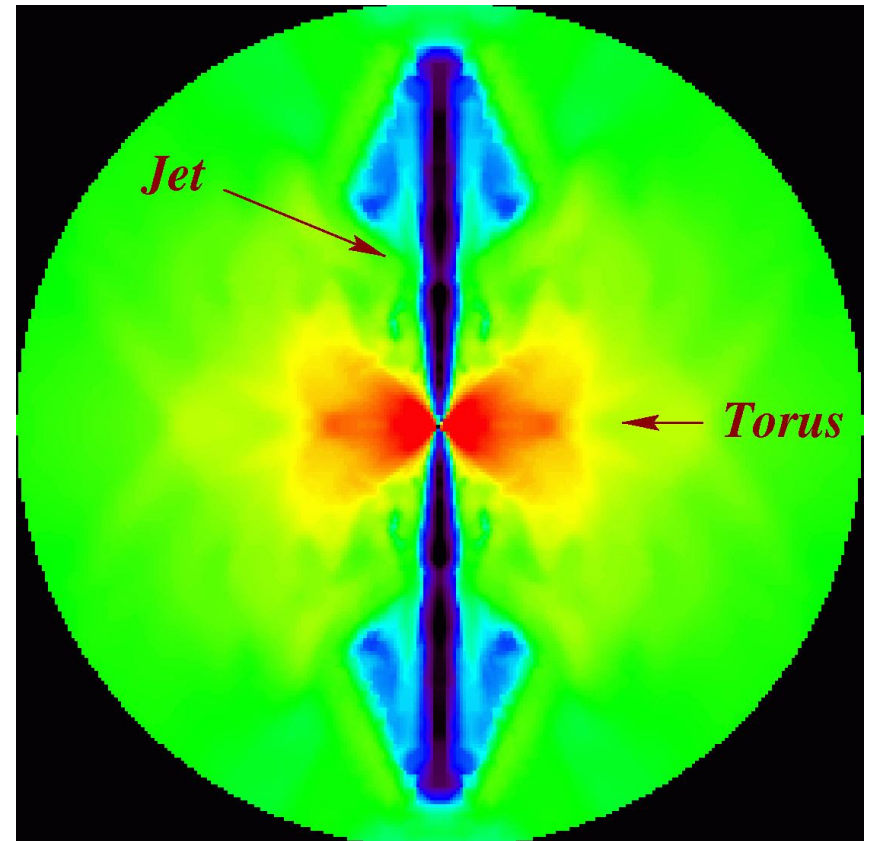
GRBs: The Most Distant Objects in the Universe

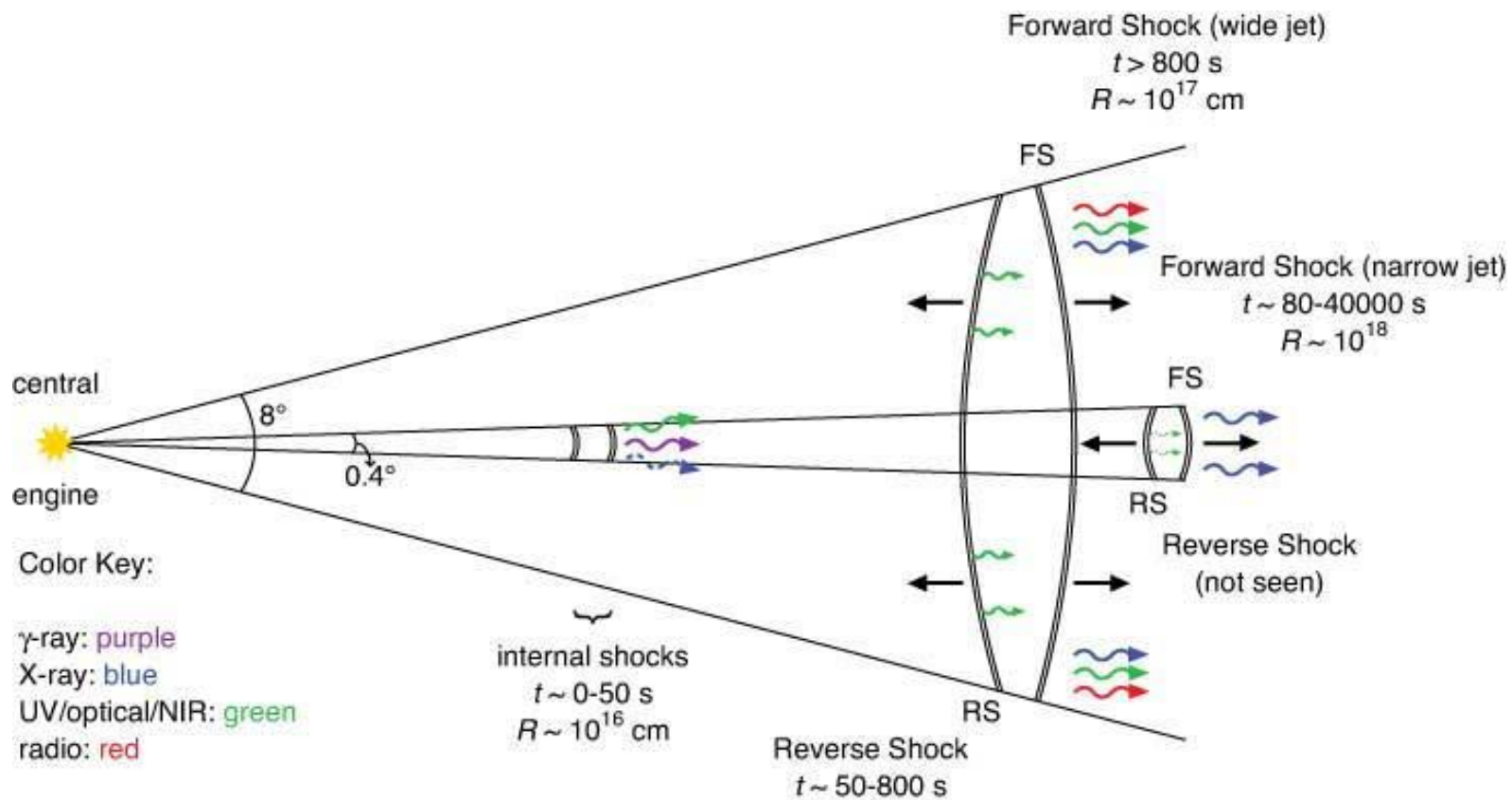


Credit: Edo Berger (Harvard/CfA)

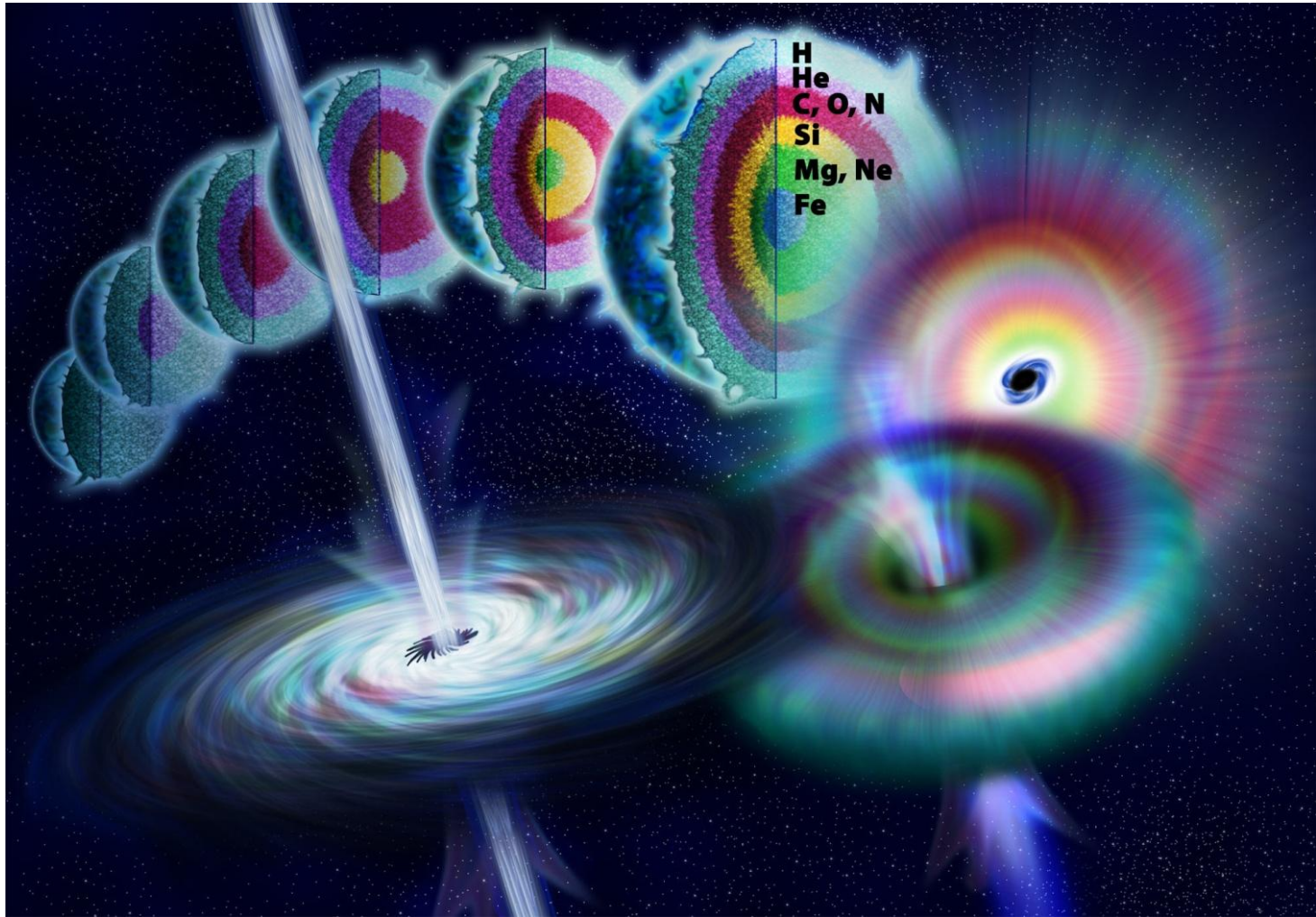
Conditions for Collapsar (Hypernova)

- At least $40 M_{\text{sun}}$ to form a black hole
- Star must be rapidly rotating to develop an accretion torus launching a jet





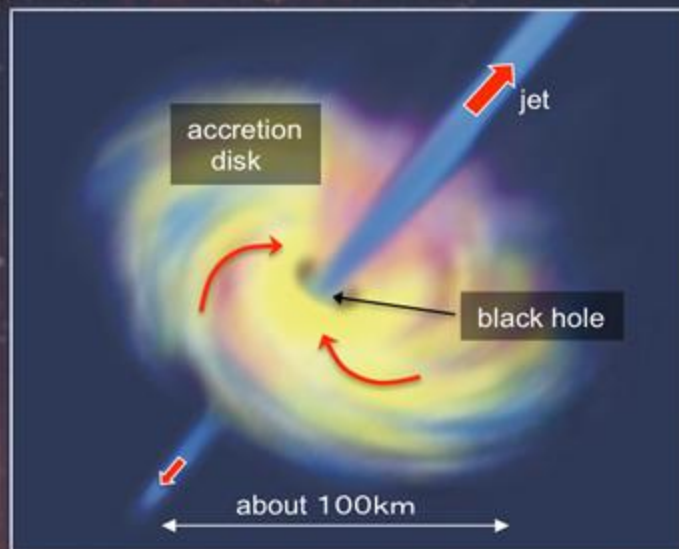
Model of a Gamma-ray Burst



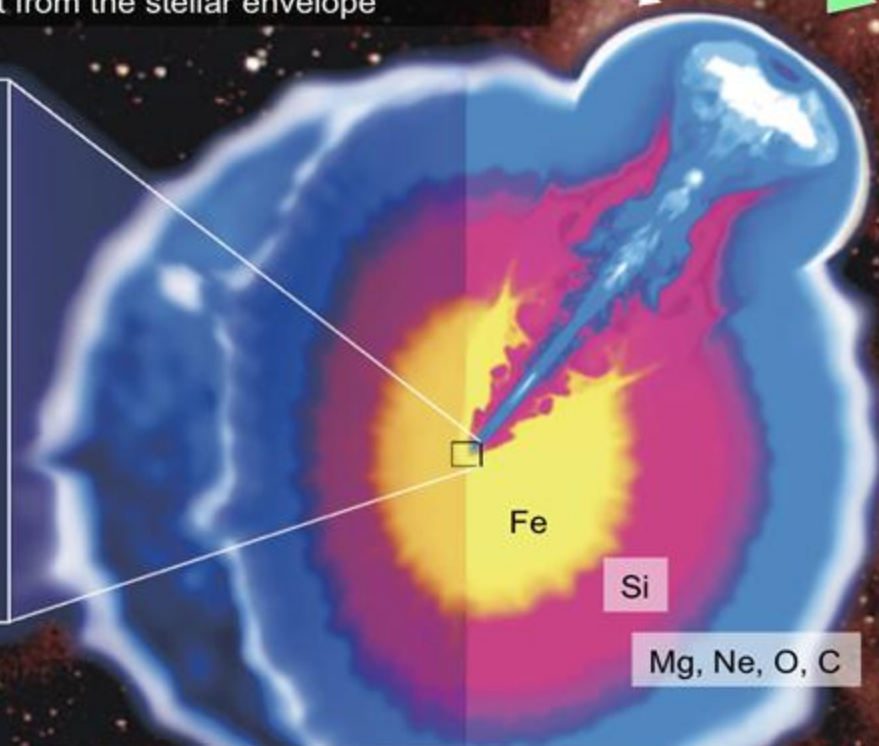
Gamma-Ray Bursts (Imaginary Picture)

gamma-rays are produced when
the jet (close to the light speed) breaks
out from the stellar envelope

Observer



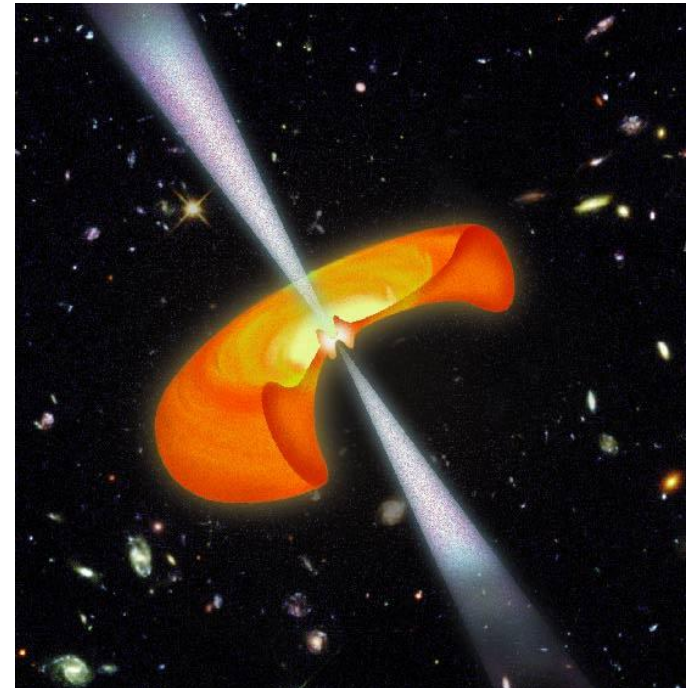
A black hole, accretion disk and jet are
formed by the gravitational collapse of
the stellar core



A very massive star (more than 20 solar mass),
whose outer envelope (hydrogen and helium) has
been removed

GRB Energy is Directed (Beamed)

- Many high energy objects in the early universe produce jets.
- If a jet is pointed at Earth, the energy would be concentrated like a flashlight beam.



Did a Gamma-ray Burst Kill the Dinosaurs??



The End







SHAW PRIZE

